

**Infrared Optical Properties of Praseodymium Copper Oxide**

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Beamline(s): U10A

**Introduction:** The material  $\text{Pr}_{2-x}\text{Ce}_x\text{CuO}_4$  has a modified tetragonal structure and becomes superconducting at  $x \sim 0.13$ , with a maximum value for the critical temperature of  $T_c \sim 19$  K at  $x \sim 0.15$ . However, unlike other known hole-doped cuprate superconductors, these materials are thought to be electron-doped [1]. Furthermore, the as-grown materials are not superconducting; instead they must be post-annealed in oxygen to induce a  $T_c$ , indicating that oxygen behaves differently in these materials than in the hole-doped cuprates. For these reasons, it is important to understand the properties of the insulating parent compound  $\text{Pr}_2\text{CuO}_4$ .

**Methods and Materials:** Single crystals of  $\text{Pr}_2\text{CuO}_4$  were grown using a CuO-based direction solidification technique [2]. The resulting surfaces are optical quality. The temperature dependence of the reflectance has been measured at a near normal angle of incidence using the Bruker IFS 66v/S Fourier transform interferometer at U10A using an overfilling technique [3]. The optical properties have been determined from a Kramers-Kronig analysis of the reflectance.

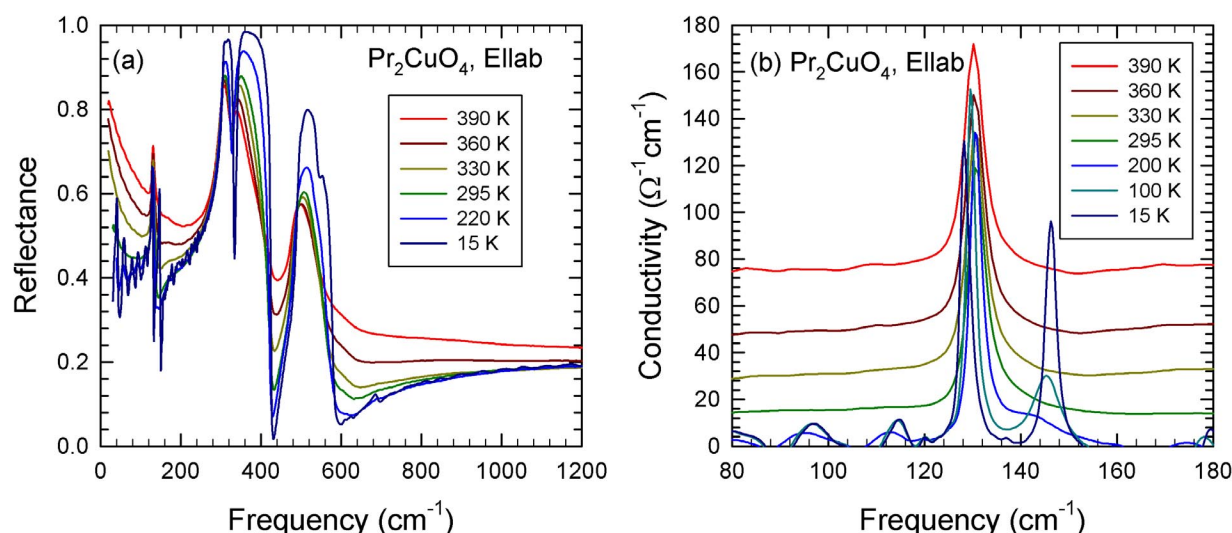
**Results:** The temperature dependence of the reflectance of  $\text{Pr}_2\text{CuO}_4$  is shown in Fig. 1(a) in the infrared (IR) region from above room temperature down to  $\sim 15$  K for light polarized in the copper-oxygen ab planes; the optical conductivity is shown in Fig. 1(b). The units of frequency are inverse centimeters, or wavenumbers. The optical properties are dominated by the four normally infrared-active  $E_u$  modes. One of the most interesting features is the sudden appearance of a new mode at  $\sim 145 \text{ cm}^{-1}$  below  $\sim 200$  K. Fringes develop at low temperature as a result of the increasingly transparent nature of the sample. Aside from the new mode there is little additional structure, making it unlikely that a structural phase transition has caused the splitting. A detailed normal coordinate analysis has been undertaken to describe the atomic displacements and the potential energy distribution of the normally IR-active  $E_u$  modes. Only the low frequency mode has any coupling between the Pr and Cu atoms. This material is an antiferromagnetic insulator, in which the copper moments are typically observed to order near room temperature. From symmetry considerations, the Pr modes should order as well. It is possible that the induced ordering of the Pr modes lifts the degeneracy of the low-frequency  $E_u$  mode, allowing the observation of this new feature.

**Conclusions:** The low frequency  $E_u$  mode in  $\text{Pr}_2\text{CuO}_4$  is observed to split into a doublet at low temperature, suggesting that the coupling between the ordered Cu moments and the Pr results in the removal of degeneracy of the doubly degenerate low-frequency  $E_u$  mode.

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**References:**

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**Figure 1:** (a) The infrared reflectance of  $\text{Pr}_2\text{CuO}_4$  at several different temperatures, (b) the conductivity.